



Moving Spore- adically:

The Spread of Sudden Oak Death in California Forests

Meet the Scientists



Dr. Davidson: ◀ My most exciting moment as a scientist came while walking in the forest in the rain, collecting bay laurel leaves infected by sudden oak death and quickly taking them to the field station for viewing under the microscope. There, on the underside of the leaves, were hundreds of *spore* sacs. Some had already released spores that were swimming in the film of rainwater across the surface of the leaf. In that one moment, I saw

the power of this invasive, disease-causing organism. Each leaf had thousands of swimming spores and there were hundreds of infected leaves on most of the bay laurel trees that year. The forest was swarming with spores to be carried in the rain onto oak trees. In this photo, I am testing diseased oaks in Mexico. Photo by Melissa Morris, University of California, Davis.

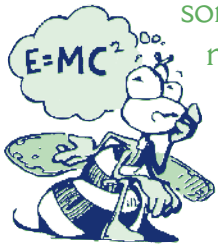
Ms. Patterson: ▶ I have really enjoyed all the hiking around I get to do in beautiful State parks. My favorite science experience was the time Kristen Falk, another scientist in this experiment, got chased by a turkey while we were tagging trees for an experiment. I don't think it liked her red pants!



Ms. Falk: ◀ This past winter I was collecting data in the woods. I was putting data into the computer from a weather station. When I'm in the woods, I hear all kinds of sounds, sometimes an owl, a hawk, a woodpecker, or a squirrel squawking at me to get out of their territory. I had the computer all set up, then I heard this distinctly different sound. It was not loud, but it gave me an uneasy feeling. I looked around for another person or other woodland creatures. Nothing. I continued working and then I heard the sound again. My ears told me the sound

was close. I looked around and saw a lot of fallen trees downhill from me. I wondered if this large tree in front of me was about to fall. I panicked and didn't have much time to think, so I grabbed my computer and ran uphill. Not a minute later, a 20-foot piece of the tree cracked off of the top and crashed to the ground, right where I had been working. My heart was racing, but I'm glad that I relied on my senses to get out of there when I did! I am the one on the right in this photo.

Thinking About Science



When scientists prepare to study something, they do as much research about the topic as possible before designing their study. That way, they will be more successful at asking the right questions and finding the clearest answers. In this study, the scientists studied the organism that causes sudden oak death. They found that the organism is like a *fungus*. Therefore, they learned everything they could about how fungi spread from place to place. By understanding how fungi spread from place to place, they were able to look for a similar process in the organism that causes sudden oak death.

Thinking About the Environment



When homeowners create gardens or do landscaping around their homes, they often use plants that are not *native* to the area in which they live. These nonnative plants are often transported from country to country, and across the country from *nursery* to nursery.

When a plant is infected with a disease, it is not just the plant that is transported from nursery to nursery. Sometimes, these plants and diseases escape into the natural environment, where they become disruptive to the natural *ecosystem*. You can see that although we usually think of plants as not

Glossary:



spore (spor): A tiny cell of a plant or animal that can grow into a new plant or animal.

fungus (fung gus): An organism without chlorophyll that reproduces by spores. Mushrooms, molds, mildews, and toadstools are types of fungus. (Plural is fungi, **fungi**).

native (nat iv): Naturally occurring in an area.

nursery (nür sür e): A place where young trees or plants are raised for study or for sale.

ecosystem (e kō sis tem): Community of plant and animal species interacting with one another and with the nonliving environment.

mobile (mō bul): Able to move from location to location.

species (spe sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

canker (kang kūr): An open sore.

broadleaf (brôd lef): Flat broad leaves.

habitat (hab uh tat): Environment where a plant or animal naturally grows and lives.

Pronunciation Guide

<u>a</u>	as in ape	<u>o</u>	as in go	<u>ü</u>	as in fur
<u>ä</u>	as in car	<u>ô</u>	as in for	<u>oo</u>	as in tool
<u>e</u>	as in me	<u>u</u>	as in use	<i>ng</i>	as in sing
<u>i</u>	as in ice				

Accented syllables are in **bold**.

being *mobile*, their reproduction and transport by humans allows them to spread from place to place. If a plant has a disease, the disease can spread as well.

Introduction

Sudden oak death is a new disease of trees and plants in the United States and Europe. Although scientists are not certain, they believe the fungus-like organism that causes sudden oak death was brought into the United States from another country. At first, the disease was found only in California (**figure 1**). Since that time, nursery plants affected with the organism that causes sudden oak death have been shipped to other nurseries across the United States (**figure 2**).

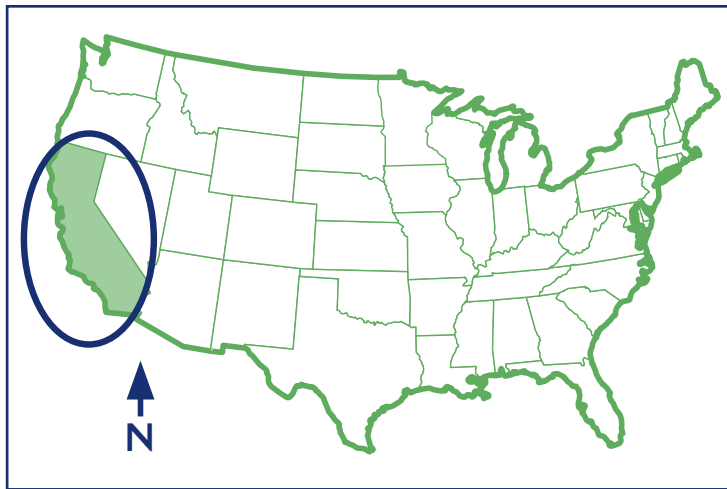


Figure 1. California.

One way the organism spreads is through the sale of infected nursery plants to homeowners or to nurseries in other locations. When such movement occurs, the organism can be spread quickly across long distances. Spraying plants with a chemical to kill the organism does not always work well enough to keep the organism from reappearing and spreading.

The organism can also spread from plant to plant. When the organism that causes sudden oak death infects a plant, it is hard to stop its spread to other plants and trees. Although the organism damages but does not kill all the tree *species* that it infects, it does kill some of them. In this study, the scientists wanted to learn how the organism that causes sudden oak death is spread from tree to tree within a forest.

Reflection Section



What is the problem the scientists wanted to study?

Which type of tree would you guess is most often killed by the organism that causes sudden oak death?

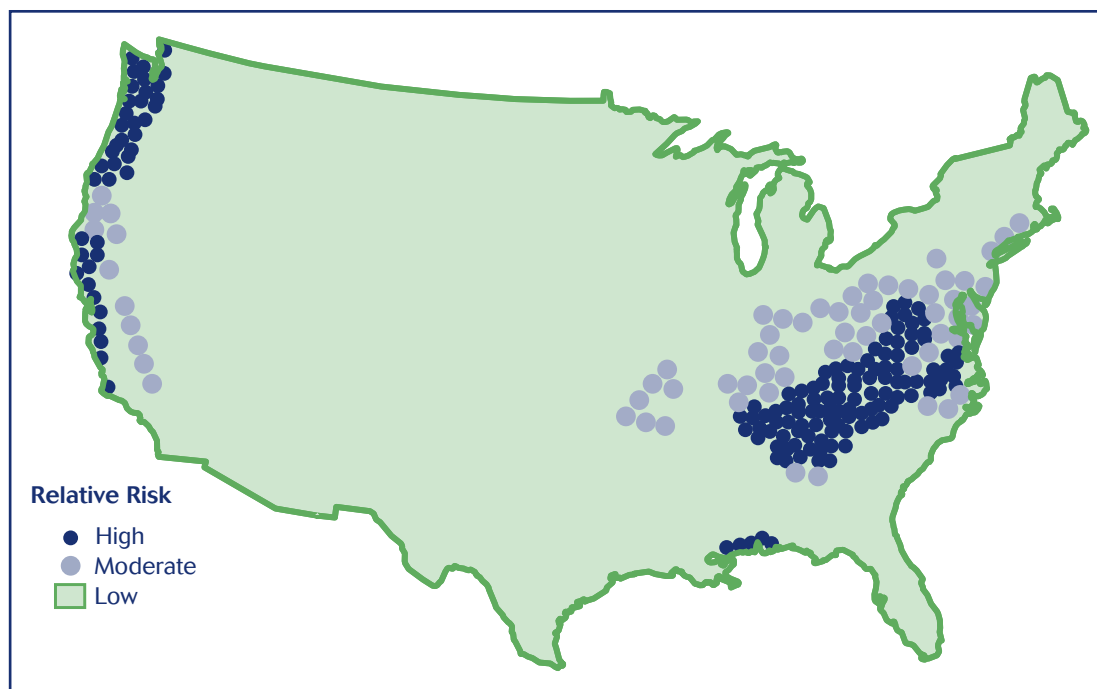


Figure 2. The location of nurseries across the United States that received plants from California nurseries that were infected with the organism that causes sudden oak death.

What is sudden oak death?

Sudden oak death is a deadly disease affecting four oak species in California and Oregon. It is caused by a fungus-like organism that produces *cankers* on the bark of oak trees. These cankers look like they are bleeding (**figure 3**). The sudden oak death organism also infects 13 other species of trees in California, including California bay laurel, coast redwood, Douglas fir, and bigleaf maple (**figures 4a–4d**). Although sudden oak death does not kill all the trees that it infects, the infection of any tree adds to the problem. When a tree is infected with the organism that causes sudden oak death, the infection enables the disease to continue to spread.

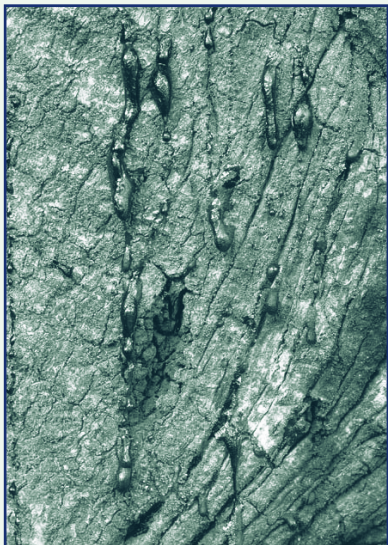


Figure 3. Canker on an oak tree caused by the sudden oak death organism. Photo by Matteo Garbelotto.



Figure 4a. The sudden oak death organism causes the death of leaf tips in bay laurels. Photo by Jeff Hall.

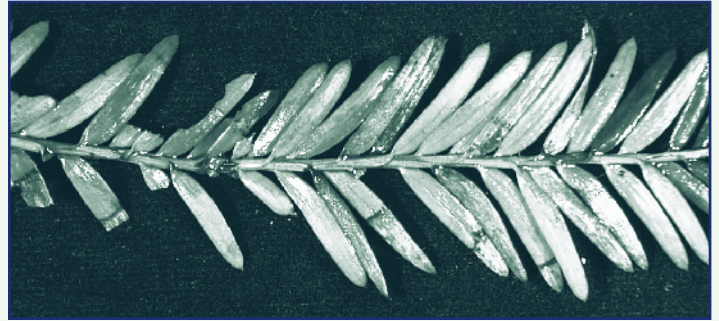


Figure 4b. The sudden oak death organism causes the death of needles on coast redwoods. Photo by Jeff Hall.



Figure 4c. The sudden oak death organism causes the stem to wilt on Douglas fir. Photo by Jenny Davidson.



Figure 4d. The sudden oak death organism causes the leaves to be scorched on bigleaf maple. Photo by Daniel Huberli.

Method

The scientists thought the organism that causes sudden oak death spreads in a manner similar to fungi (**figure 5**). This similarity includes the production of spores (**figure 6**). The scientists wanted to learn how the organism's spores move from tree to tree throughout a forest. The forest they studied contained both evergreen trees and *broadleaf* trees. The scientists knew that spores of fungi are often transported by wind and water and through soil. Within a forest, sources of water include rain and streams. Soil containing spores can be washed into streams or splashed onto the leaves of new plants.

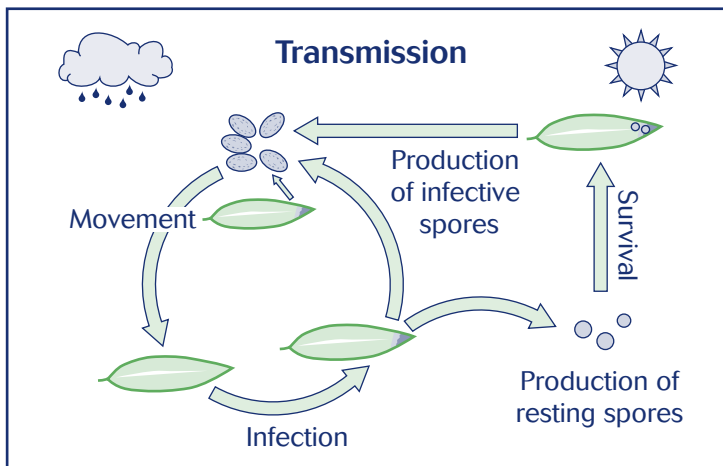


Figure 5. The cycle of reproduction of the sudden oak death organism.

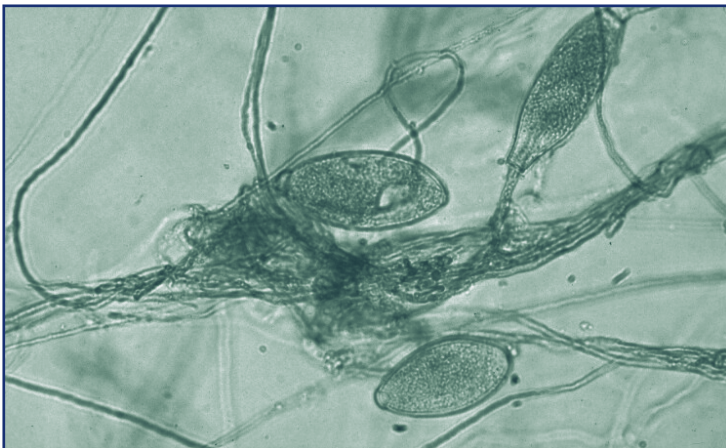


Figure 6. Spores from the organism that causes sudden oak death. Photo by David Rizzo.

Brain Crunches

Look at figures 4a–4d. Which are evergreen trees and which are broadleaf trees?

The scientists studied an area of land covering 166 hectares in California. Within this area of land, 17 percent of the coast live oak and 82 percent of the bay laurel were affected by the organism that causes sudden oak death. Sudden oak death can kill as much as 20 percent of the coast live oaks it infects in a given area (see figure 3 in the “Introduction” section).

Bay laurel trees are not killed by sudden oak death disease, but the disease still causes problems for the tree. The bay laurel tree's ability to photosynthesize is reduced and more leaves are lost from the tree. This loss is significant because bay laurel trees provide needed *habitat* and food for wildlife. Even though bay laurel trees are not killed by sudden oak death, the organism produces millions of spores while it is on the leaves. These spores may be spread to oaks, which can be killed by the organism that causes sudden oak death.

The scientists placed 30 traps to catch rainwater across the area of land (**figure 7**). They placed the traps throughout the area and collected rainwater over 2.5 years. During the rainy season, they collected the rainwater every 10 days. During the summer, when there were few rainstorms, they collected rainwater after each rain. The scientists filtered the rainwater using a very fine filter. This filter was small enough to trap the spores. The scientists performed tests to make sure the spores were the ones that cause sudden oak death. In this

Number Crunches

How many acres are equal to 166 hectares? Multiply 166 by 2.47 to find out.



Figure 7. Rainwater traps made out of a vinyl sheet were stretched over a frame and folded over to make a funnel. A 1-gallon jar placed at the end of the funnel collected the rainwater.

way, the scientists were able to estimate how many spores would be released from infected trees during a rainstorm.

To determine how far the spores travel while it is raining, the scientists put buckets in a meadow at the edge of the forest. Bay laurel trees affected by sudden oak death disease were growing at the edge of the meadow. During a rain, the scientists assumed some spores would travel away from the bay laurel trees, using windblown raindrops as their vehicles. The scientists placed buckets 0 meters, 5 meters, and 10 meters away from the trees in the meadow (**figure 8**). They collected the rainwater and filtered it in the same way they filtered the rainwater collected from the traps.

The scientists also studied how far spores could travel down a stream. The scientists



Figure 8. The buckets placed in a meadow near the forest edge. Photo by David Rizzo.

placed leaves into a screen bag at three locations. They put the bags of leaves in the stream and tied them so they could not float away. If spores were present in the water, the trapped leaves would become infected. The first location was still in the study area. The second location was outside the study area but still in the forest where infected trees were growing. The leaves placed at the third location were 1 kilometer outside the forest (**figure 9**).

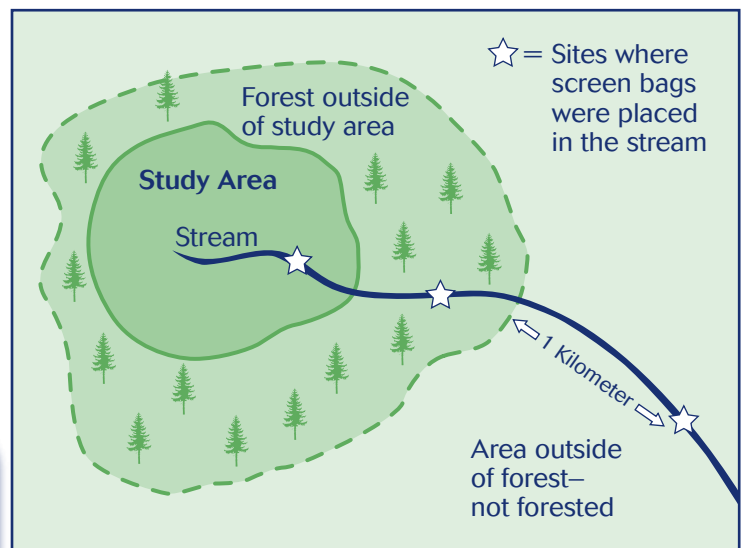


Figure 9. Locations where the trapped leaves were placed in the stream.

Number Crunches

🌿 How many feet is zero meters? Five meters? Ten meters? Multiply the number of meters by 3.280 to find out.

Finally, the scientists wanted to know whether spores could be transported on people's shoes. For this part of the study, the scientists had the help of students like you. Fifteen students hiked a trail in the study area. They hiked on 3 different days, with five students hiking each day. The scientists repeated this experiment at two different times. The distance the students hiked was 2.4 kilometers. At the end of the students' hike, the scientists scraped the soil from the students' shoes into 15 separate bowls. The scientists tested the soil in each bowl for the presence of spores. They then counted the number of students who had transported spores on their shoes.

Number Crunches

- 🌿 How many miles did the students hike? Multiply the number of kilometers by .621 to find out.
- 🌿 How many total students were involved in the experiment?

Reflection Section



- 🌿 What would the scientists learn by comparing the number of spores found after a rain in buckets placed in increasing distances from infected bay laurel trees?
- 🌿 What is the difference between the spores found in the rainwater traps and in the buckets?
- 🌿 What would the scientists learn from floating leaves in the stream?
- 🌿 What would the scientists learn from the students' hike?

Findings

The scientists found spores in the rain traps placed throughout the forest during the rainy season but not during the summer. At the beginning of the rainy season, the scientists found fewer spores than at the end of the season. The scientists found that the number of spores caught in the traps, however, varied from place to place and from year to year.

The scientists found that the farther away from the forest edge the buckets were placed, the fewer spores were trapped (**figure 10**).

The scientists found that the leaves floating in the stream within the study area became infected with the sudden oak death organism. During the rainy season, they also found that spores were present in the stream at both other locations, including the location 1 kilometer downstream from the forest. During the dry season, the stream dried out in the forest, and the scientists did not find any spores downstream during that time.

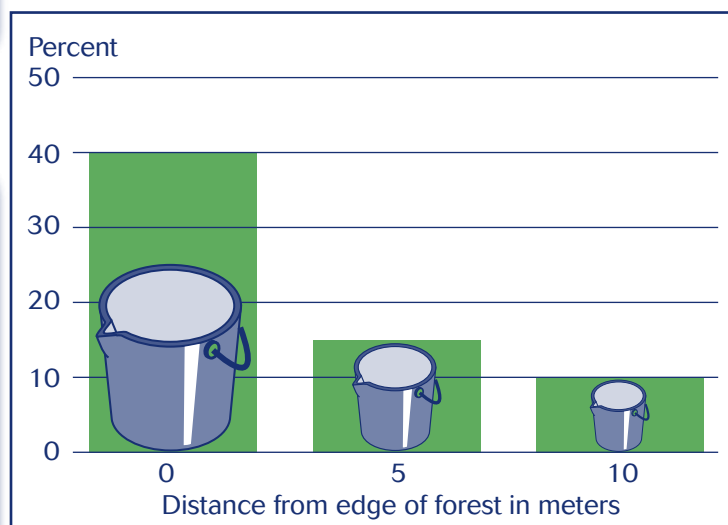


Figure 10. Percentage of times buckets were found with spores in the rainwater.

Number Crunches

- 🌿 How many miles is 1 kilometer? Multiply the number of kilometers by .621 to find out.

Of the 30 students who hiked 2.4 kilometers, 12 of them picked up spores in the soil on their shoes. Forty-seven percent of the first 15 students' shoes and 33 percent of the second 15 students' shoes had spores in the soil that had clung to their shoes.

Reflection Section



- ✿ Basing your answer on the findings, would you say that sudden oak death can be transported by water? Why or why not?
- ✿ Basing your response on the findings, would you say that people can transport the spores that cause sudden oak death? Why or why not?
- ✿ Basing your answer on the findings, under what weather conditions would you say the transportation of spores is more likely to occur?

Discussion

The findings in this study are similar to research done on similar organisms. In other words, the organism that causes sudden oak death disease is transported from tree to tree in a manner similar to other fungus-like organisms. The presence of this organism is significant because when it is transported to new oak trees, it can cause the death of those trees. The scientists found that this organism is most likely transported from bay laurel trees, where the spores infect the tree but do not kill it.

This study showed how far the organism can travel through rain, streamwater, and soil. In particular, the organism can travel long distances down streams and on the shoes of hikers. Think about the possibility of transmitting the organism that causes sudden oak death across the country from nursery to nursery. If what happened in California could happen in other States, think about what might happen if the organism spread into forests across the United States. Look again at figure 2 in the "Introduction" section. Could sudden oak death get started in your State or in a State near you? The organism that causes sudden oak death is a new invasive species and not much is known about it outside California. Because it can kill oak trees, this is a disease to which we should pay attention. ■

Reflection Section



- ✿ Do oak trees live in your area? What do you think would happen if sudden oak death began to kill those trees?
- ✿ Do you think research should be done on sudden oak death outside California? Why or why not?

From: Davidson, J.M.; Wickland, A.C.; Patterson, H.A.; Falk, K.R.; Rizzo, D.M. 2005. Transmission of *Phytophthora ramorum* in mixed-evergreen forest in California. *Phytopathology*. 95(5): 587–596.



In this FACTivity, you will learn about the American chestnut tree and compare its story to the threat of sudden oak death disease.

The American chestnut was a large tree that grew across the Eastern United States to the Ohio Valley. American chestnut trees could grow so large that their trunks sometimes reached 5 feet across. The American chestnut was a common tree. Its nuts, which were tasty and nutritious, were used by both wildlife and people. People especially liked to eat roasted chestnuts. (Do you remember the holiday song, “Chestnuts Roasting on an Open Fire”?) The wood from American chestnuts was used for furniture and to build framing for barns. The trees were so numerous that their white blooms often made the forests look like they were snow capped.

In 1904, a fungus-like organism was brought to the United States. No one knows exactly how the organism came to the United States. Some think it may have come on nonnative chestnut trees imported from Asia. This organism enters the bark of American chestnut trees and kills everything above the place of



entry. Thus, although the chestnut trees are not killed by the organism, they are reduced to nothing more than shrub-like sprouts. Within 50 years, all large American chestnut trees were gone.

Today, scientists think they will be able to bring the chestnut tree back. Even if they are able to do so, it will take years for the trees to grow. Scientists are not sure how the native forest will adapt to this new type of large chestnut tree.

In this research article, you read about the threat of sudden oak death disease. It may seem hard to believe that our Nation’s big, strong oak trees could be in danger

Sudden oak death Web resources:

<http://www.suddenoakdeath.org>

<http://www.na.fs.fed.us/sod/>

American chestnut information from S.L. Anagnostakis
(e-mail: Sandra.Anagnostakis@po.state.ct.us) and
<http://munic.state.ct.us/BURLINGTON/chestnuttree.htm>.

because of a fungus-like organism. The American chestnut story shows that the threat of sudden oak death could be a disaster. It could change the look and ecology of our Nation's forests, parks, schoolyards, and backyards.

In this FACTivity, you will ride a time machine into the future. Imagine you are an adult with children the age that you are now. Since the time you were their age, the organism that causes sudden oak death has spread across the United States and killed all the oaks. You and your children are now



living in a world without oak trees. Your children have asked you what the forests and parks were like when oak trees were alive. They want to know if you climbed oak trees, if you played under them, and what they looked like.

Write a story for your children about living with oak trees. If you have a favorite oak tree, you can write about that tree. You could tell about climbing an oak tree or building a tree house, or you could write about that one big oak tree standing alone in the park. You may include drawings with your story.

After completing your story, share your story with your classmates. You may post your stories and drawings on a display. As a class, discuss what benefits of oak trees were identified in the stories. How might your lives be different if oak trees did not exist? Basing your response on the class discussion, do you think it is important to guard against the spread of the organism that causes sudden oak death disease? Why or why not?

Extension: Students who want an extra challenge could do research to learn more about recent efforts to bring the American chestnut back to American forests.

If you are a Project Learning Tree-trained educator, you may use PLT Pre K–8th Activity Guide #77, “Trees in Trouble,” as an additional activity resource. This activity teaches how to read signs and symptoms of stressed trees.